

A Recent Expansion of its Queensland Range by *Eupristina verticillata*, Waterston (Hymenoptera, Agaonidae, Agaoninae), the Pollinator of *Ficus microcarpa* L.f. (Moraceae).

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In 2004, the first *Ficus microcarpa* seedlings were observed self-establishing in Brisbane, Queensland. Prior to this the only *F. microcarpa* in the city were cultivated specimens. This self-establishment is a certain indicator of the presence of *Eupristina verticillata*, the obligate pollinator wasp of *F. microcarpa*. A *Ficus* species must exceed a critical population size (CPS) for its pollinator, a species of agaonid wasp, and other non-pollinator symbionts to colonize a new area and then maintain their new population. This CPS has often been estimated to be approximately 300 mature trees. The CPS for *F. microcarpa* has been exceeded in Brisbane for some time. Brisbane has been colonized by the wasps *Odontofroggattia galili* (a gall species), since at least 1975, and *E. verticillata*, since at least 2004. Previously, the southern extreme of the range of *E. verticillata* was central Queensland, approximately 600 km north of Brisbane. This was probably achieved through a stationary, inland, trough system drawing tropical air to the southeast over a few days. Brisbane's new *E. verticillata* population may not persist, as it must compete for short-styled *F. microcarpa* flowers with a long established *O. galili* population. Further, it must contend with a winter of greater duration and lower mean temperature than its tropical origins may allow.

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INTRODUCTION

On March 26, 2004, four *Ficus microcarpa* L.f. seedlings were found growing on a monument and road reserve infrastructure at North Quay, Brisbane, Queensland. The largest of these was approximately 100 mm in height and diameter (Figure 1). Prior to this the only *F. microcarpa* occurring in Brisbane were deliberately cultivated specimens. The Settler's Monument, which identifies the nascent colony of Moreton Bay's first graveyard, is located under the canopy of a *F. microcarpa* (Figure 2) that is part of an ongoing phenology study begun in September 1996. The presence of these seedlings indicates the presence in Brisbane of the obligate pollinator of *F. microcarpa*, identified by Wiebes (1994) as being *Eupristina verticillata* Waterston, whose former southern limits were in central Queensland. No *F. microcarpa*

seedlings were noted in Brisbane's CBD prior to March 2004, and none were located in a major 1996 *Ficus* hemi-epiphyte audit of 21 Brisbane parks that involved checking 3,580 trees and palms (McPherson 1999). *Ficus microcarpa* syconia investigated by the author at various times prior to March 2004 contained only the non-pollinator wasp *Odontofroggattia galili* Wiebes, although *E. verticillata* would have arrived prior to then but went undetected.

As a genus *Ficus* has two distinct characteristics: the floral receptacle or syconium (the 'fig') containing large numbers of male and/or female flowers; and apart from rare exceptions (Kendelhue and Hockberg 1997) each *Ficus* spp. being exclusively pollinated by its own unique species of agaonid wasp. Further, a 'typical' individual *Ficus* exhibits strict synchrony of syconial initiation and development, but does so asynchronously relative to local conspecifics. While

a *Ficus* population may exhibit seasonal highs and lows in syconial production, at any time in a sufficiently large population some individuals bear syconia at various developmental stages. Departures from this 'typical' pattern occur, as syconia in all stages of development within a single tree have been reported for *Ficus aurea* Nutt. (Bronstein and Patel 1992), *Ficus benjamina* L. (Corlett 1984), *Ficus macrophylla* Desf. ex Pers. (Gardner and Early 1996), and *F. microcarpa* (Corlett 1984; Bronstein 1989).

The syconia of monoecious *Ficus* spp. such as *F. microcarpa* are functionally protogynous. Female pollinator wasps depart maturing syconia when male flowers are shedding pollen. Entering a young syconium when female flowers are receptive, they gall the flowers with short styles and pollinate those with long styles. Adult pollinator wasps live only two to three days, so rapid location of receptive 'female phase' syconia year round is critical to their persistence in an area (Ware and Compton 1994; Gardner and Early 1996). Various estimates have been made regarding the Critical Population Size (CPS) of *Ficus* spp. that allows pollinator persistence. There is a degree of 'in principle' consensus that approximately 100 *Ficus* individuals are required for establishment of wasps and approximately 300 individuals needed for long-term wasp persistence (McKey 1989; Thompson, *et al.* 1991). Different *Ficus* spp. seem to exhibit longer or shorter mean periods between crops. This would affect CPS, as would asynchronous intra-tree production of syconia. More study is required to ascertain the CPS for different *Ficus* spp. and even of a single *Ficus* species growing in different climates.

Many non-pollinator agaonid wasp species share syconia with pollinators. In the case of *F. microcarpa*, *O. galili* is a common 'cuckoo' species in syconia of *F. microcarpa*. It has been present in Brisbane since at least 1975 (Boucek 1988) and probably considerably longer. The long-term presence of *O. galili* in Brisbane indicates that *F. microcarpa* exceeds minimum CPS for the wasp population's persistence. Survival of most non-pollinator agaonids depends on cohabitation of syconia with pollinators as unpollinated syconia usually abscise (Ramirez and Montero, 1988). However, abscission can be prevented by the presence of galls resulting from a few non-pollinator agaonids such as *Odontofroggattia* Ishii spp. (Boucek, 1988), allowing development of seedless, mature syconia.

It is likely that most agaonid wasps disperse only short distances. However, reports of wasps covering long distances exist. Several Australian agaonid wasp species have become naturalized in New Zealand, presumably after being caught in a major air current

(Gardner and Early 1996). Stowing away in aircraft or vehicles also allows long dispersal distances (McKey 1989).

Ficus microcarpa occurs naturally in suitable habitats throughout the tropics of south and east Asia and Australia, with central Queensland as the 'natural' southern limit for *F. microcarpa* in Australia (Chew 1989). Due to its hardiness, beauty and excellent shade it has been widely planted in the tropics and subtropics of the world. It is a common park and street tree in Brisbane, thriving in the moist-subtropical climate. Huge specimens dating from the 19th and early 20th Centuries can be found in Brisbane's CBD and inner suburbs. Innumerable small to medium sized specimens, planted in the late 20th to early 21st Centuries are growing in parks and along roads throughout the city and frost-free areas of southeast Queensland.

Ficus microcarpa is an invasive urban 'weed' in the Americas, Hawaii and elsewhere, beginning its invasion after the introduction of its pollinator (McKey, 1989). Finding a vacant ecological niche, both plant and pollinator rapidly established and spread. Given its reputation as an invader of urban space, and since it is autochthonous to much of coastal Queensland, the question arises as to why it has not reached and survived in Brisbane prior to this recent occurrence.

MATERIALS AND METHODS

Monthly surveillance of 39 mature *Ficus* of various species, including eight *F. microcarpa*, has been undertaken since September 1996 for Brisbane's



Figure 1. A *Ficus microcarpa* seedling at left and a *Ficus benjamina* seedling at right, growing in the base of the Settler's Monument, North Quay, Brisbane, 26/03/04. The *F. microcarpa* has an erect habit with mostly obovate, flat leaves, while *F. benjamina* has a pendulous habit with mostly ovate, curling leaves.



Figure 2. The Settler’s Monument, North Quay, Brisbane, located beneath a medium-sized *Ficus microcarpa*, 26/03/04.

CBD. Data on the phenology of these *Ficus* spp. and any other interesting observations have been recorded. These data included notes on any seedlings appearing near mature trees.

On March 27, 2004 ‘male phase’ syconia that had no wasp exit holes were collected from an immense *F. microcarpa* in the Brisbane City Botanic Gardens and incubated in glass jars covered by paper towels and sealed with rubber bands. After two days, wasps that had emerged were killed and *O. galili* identified

by using the key of Boucek (1988) and *E. verticillata* using the Wiebes (1994) key. During each subsequent month, syconia exhibiting exit holes were collected from each of the eight study trees, dissected, and investigated for seeds and galls. Seeds and galls were easily differentiated as galls were either hollow or contained pre-emergent wasps.

Using mean monthly temperature data supplied by the Regional Observations Database (Accessed July 16, 2004) of the Brisbane Office of the Bureau of Meteorology, mean monthly minimum temperatures for Brisbane Aerodrome during the months from May to September during the years in the periods 1950-99 and 2000-03 were compared using Students t test.

RESULTS

The four seedling *F. microcarpa* were noted during the phenology audit for March 26, 2004. Subsequent to the initial discovery, two new *F. microcarpa* seedlings germinated on the Settler’s Monument or nearby infrastructure. As yet they have not been found establishing in other areas of the CBD.

Syconia that lacked exit holes released both *E. verticillata* and *O. galili* during incubation. If possible, specimens of both species will be lodged with the Queensland Museum should later verification of either taxon be thought necessary. Syconia from which wasps had departed contained a mix of seeds and galls until August 2004, when only galls could be found. Since germination was occurring naturally in the CBD the viability of the seeds was not tested.

Only July returned a significant difference between monthly mean minimum temperatures in the blocks 1950-99 and 2000-03 (Table 1). The July mean of 7.8°C for 2000-03 was less than the 9.5°C mean of for 1950-99.

Table 1. Comparisons of mean monthly minimum temperatures at Brisbane Aerodrome, Eagle Farm, for the years in the periods 1950-99 and 2000-03.

	May	June	July	August	September
Mean minimum temp. 1950-99	13.8°C	11.0°C	9.5°C	10.1°C	12.5°C
Mean minimum temp. 2000-03	12.6°C	10.2°C	7.8°C	9.3°C	12.4°C
Student’s t	1.862	1.219	2.249	1.299	0.346
Significance	P = 0.680	P = 0.228	P = 0.029	P = 0.200	P = 0.731

DISCUSSION

At some time between 1999 and 2004, *E. verticillata* reached Brisbane, found and pollinated a number of *F. microcarpa*. Seed from one of these trees has been germinating in cracks in the mortar of the stone-block Settler's Monument and in the surrounding footpath on North Quay. The precise date of the arrival is unknown but, from the size of the seedlings initially found, it would be closer to five years.

As per the dispersal of Australian agaonids to New Zealand (Gardner and Early 1996) it is probable that *E. verticillata* travelled south in a rapidly moving, surface air mass. If this was the case, it is likely that quite a few *F. microcarpa* were pollinated in subtropical coastal Queensland and as far south into New South Wales as the air mass penetrated.

It would require a northwesterly wind blowing steadily at over 12.5 kmh⁻¹ to move wasps the approximately 600 km from the Rockhampton area to Brisbane in less than two days. While unusual, this can happen when trough systems sit for a few days over inland Queensland. Tropical air is pulled southeast, resulting in hot northwesterly winds blowing over southeast Queensland and northeast New South Wales. Clouds of fig wasps emerging from natal syconia could be caught up in this air mass.

Will *E. verticillata* persist in Brisbane? Possibly. A likely pattern is occasional population irruptions followed by local extinction. Wasps were still present in good numbers in June 2004 and successfully dispersing between trees, but seed could not be located during August, indicating a population decline. Hypothetically, if *E. verticillata* had dispersed to Brisbane at some time prior to 1999 it may have failed to establish due to strong competition for short-styled flowers from *O. galili*. Gardner and Early (1996) noted a decline in the numbers of pollinator wasps per syconia after the dispersal of non-pollinator agaonids to New Zealand. Also, Brisbane's winter may be too long and its temperatures too low for the survival of *E. verticillata*.

Ultimately, *E. verticillata* has had over a century in which to establish a permanent population in Brisbane but has yet to succeed. Any earlier failure to establish a permanent population can not be attributed to climatic factors, as Brisbane's winters in the early 21st Century were marginally cooler than winters in the second half of the 20th Century. It may be successful if the steadily expanding *F. microcarpa* population has reached a size where a residue *E. verticillata* population could survive competition and

winter in suitable refugia, and then expand rapidly as the season warmed. A suitable refugium would have a warmer microclimate and a large number of *F. microcarpa* growing within it. This would ensure short pollinator dispersal flights, less stress during cold, adverse weather and consistently available 'female' phase syconia.

If *E. verticillata* does become established, then *Ficus microcarpa* would begin to establish itself as a hemi-epiphyte and lithophyte throughout Brisbane. While a boon for local frugivores, this would be a disaster for the local authority and other property managers. *Ficus* spp. have tremendous potential to damage trees and infrastructure. At least six *Ficus* spp. are already establishing in Brisbane as hemi-epiphytes or lithophytes (McPherson 1999), causing various amounts of damage and requiring ongoing attention to minimize their impact. None of these species has a literature reputation for invasiveness to compare with *F. microcarpa* (Starr 2003). Already hard-pressed and under-funded vegetation control services would be presented with yet another problem plant to manage should *F. microcarpa*, the acknowledged 'Big Kahuna' of invasive *Ficus* spp., begin establishing in numbers in Brisbane.

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